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RoboCupRescue - Robot League Team SHINOBI (Japan)

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Abstract. We will operate three robots by teleportation at the competition: two wheel type and one 4-leg type. Each type of the robots has its own unique control mechanism and possesses different advantages when traveling in various environments. One wheel type is “FUMA” which participated in the last competition. We have installed new features: the auto/semi-auto map building, the image stabilization and the bird’s eye view user interface. We are developing two new robots. HANZO is the wheel type robot which can vary its structure and traverse even with inverted pendulum structure. The other is a 4-legged type robot with the image stabilization and foot probe function. The implemented intuitive GUI system will help an operator to easily control our robots.

1. Team Members and Their Contributions

- Noritaka Sato: Team leader
- Naoji Shiroma: System development
- Tetsushi Kamegawa: Mechanical design

- Yu-huan Chiu: System development, Mechanical design, Operator
- Motoyasu Tanaka: Operator
- Norihiko Wada Mechanical design, Operator
- Hideaki Nii System development, Mechanical design
- Masahiko Inami: System development, Mechanical design
- Fumitoshi Matsuno: Advisor
- Hideki Igarashi: Mechanical design

2. Operator Station Set-up and Break-Down (10 minutes)

We have participated in several rescue robot competitions and have many experiences of this operator station set-up and break-down. In the case of FUMA[1], we packaged everything we need for the robot operation on one tray and achieved quick set-up and break-down at the last competition. We will use this system again for this competition and as well as for the other robots.

3. Communications

We will operate three robots: two wheel type (Figure 1, Figure 2), and one 4-legged type (Figure 3). The communication methods for the robots are shown in Table 1.

4. Control Method and Human-Robot Interface

Considering the difficulty of autonomous robot control in current technology, we will operate the robots by teleoperation, especially for practical rescue robots it is important to improve such ability. The problem is how we can improve it. Our approach is as follows:

- Use a commonly used game pad (PlayStation 2 Game Pad) which is easily controllable and has been recognized in the world as a very suitable robot control interface device.
- Remote control based on bird's eye view. This innovative viewing method helps an operator to easily understand robot's situation in an unknown environment and this is currently under development to improve teleoperation ability (Figure 4)[2].
- Image stabilization system which is compact and environment independent have implemented improve remote controllability (Figure 5).

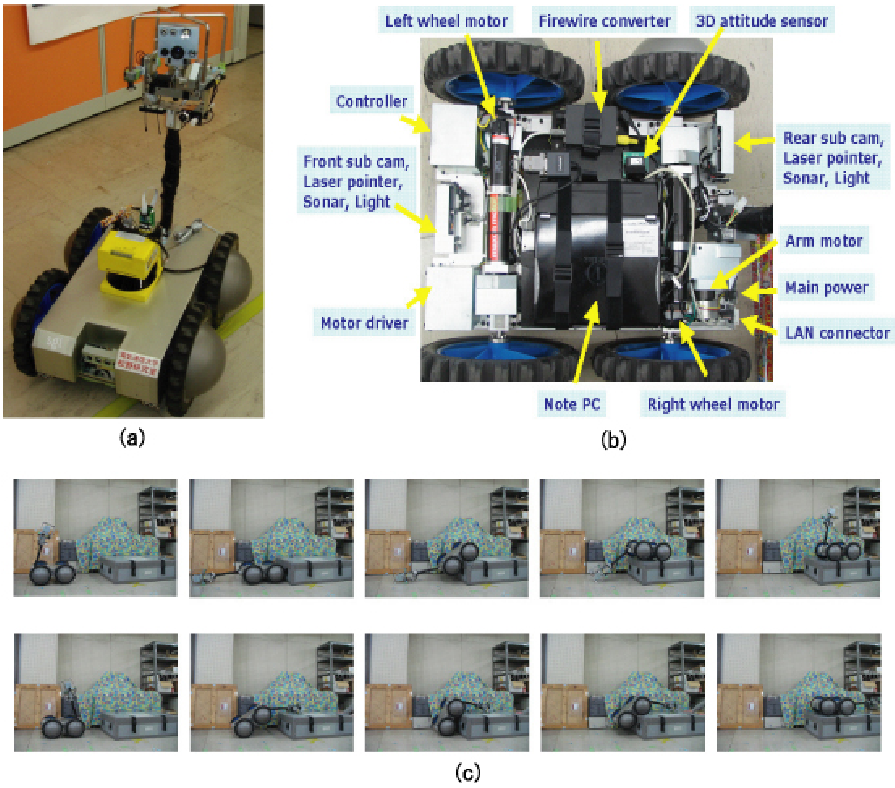


Fig. 1. (a): FUMA - environment information collection type robot; (b): Internal device arrangement; (c) Using the 1-DOF arm to climb over a high obstacle. The obstacle is 33 cm in height. The upper row shows the climbing over procedure facing forward. The lower row shows facing backwards.

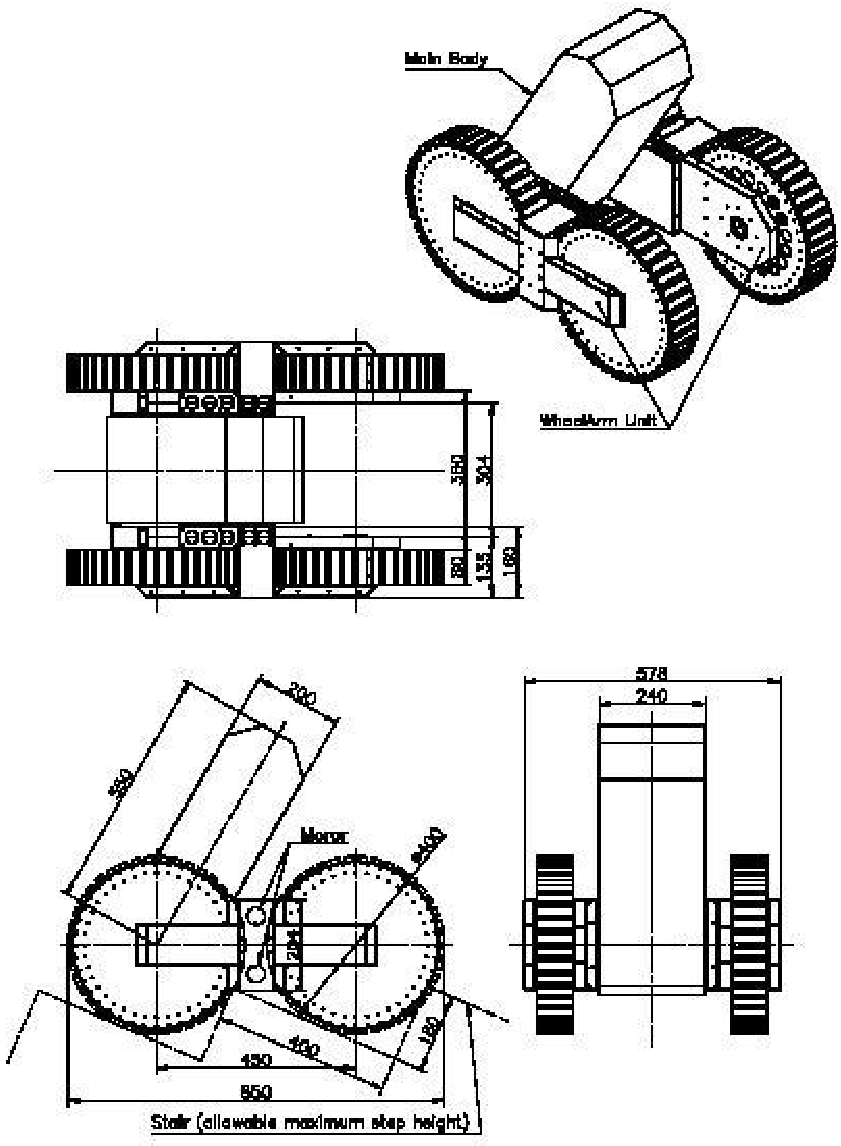


Fig. 2. HANZO – A high maneuverability variable structure wheeled robot. Capable of conquering various terrains and able to transform into inverted pendulum mobile robot mode.

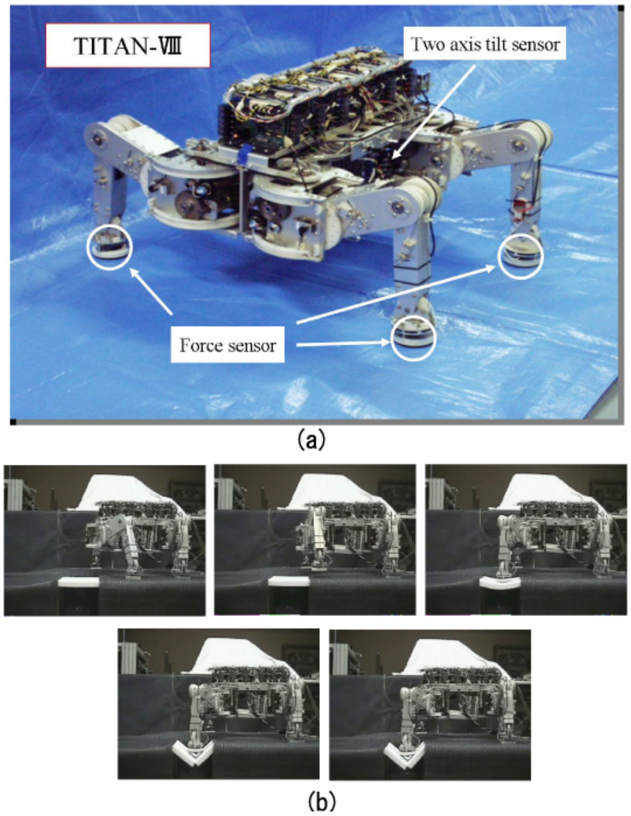
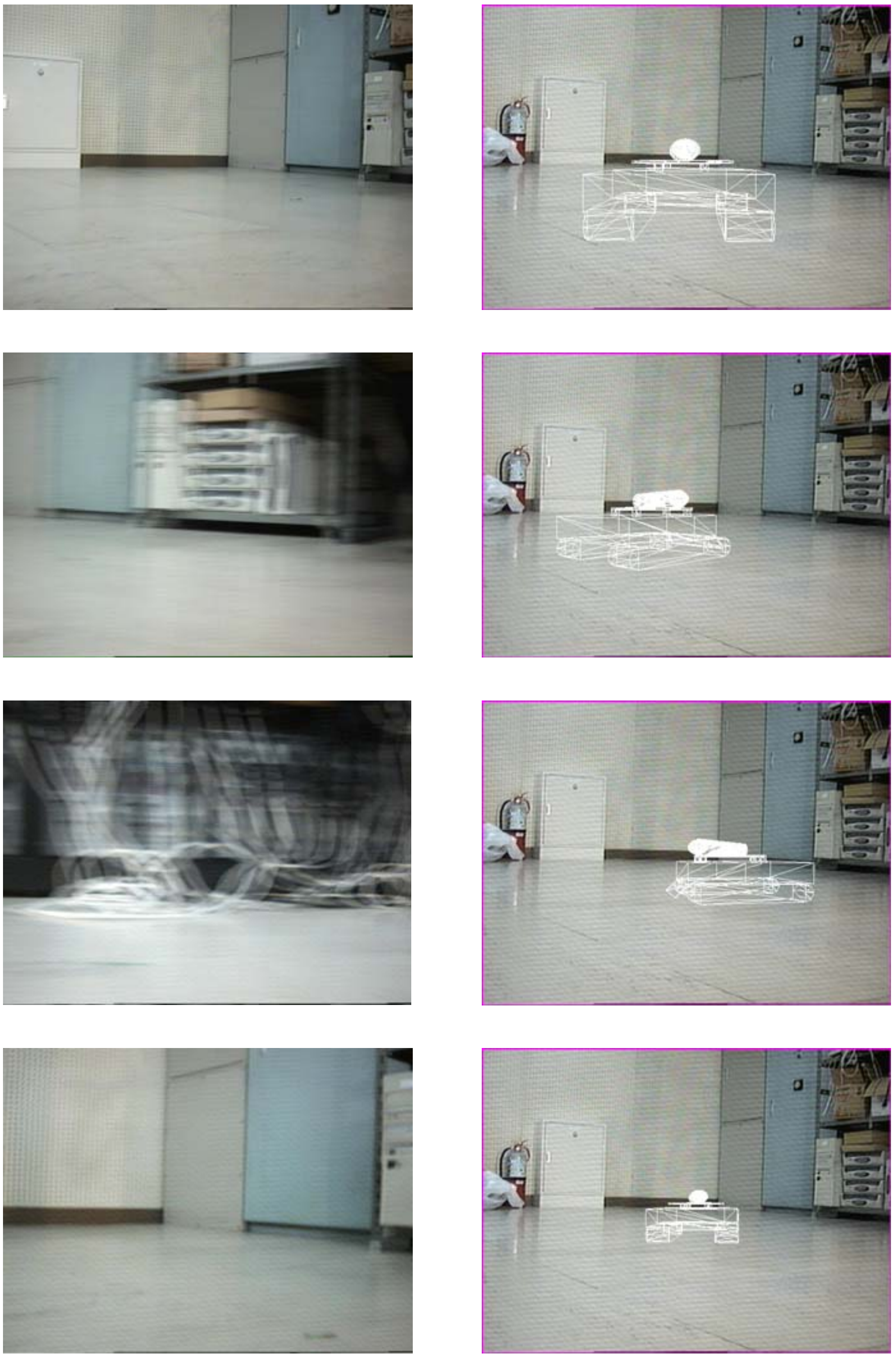


Fig. 3. (a): TITAN - 4-legged type middle size robot; (b): foot prove function – even though the environment is unstable, the robot will not loose its balance.

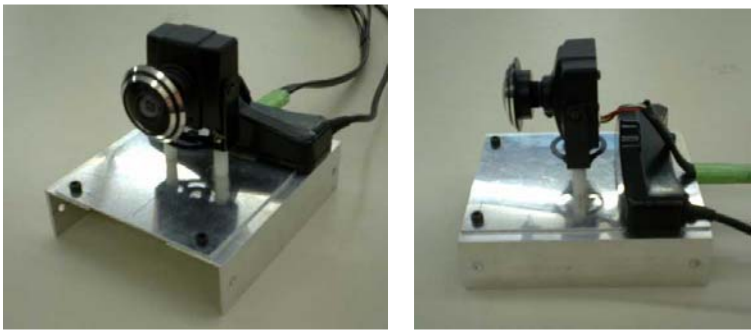
Table 1. Team SHINOBI wireless communication table

Robot	Radio frecuency	
	Control	Camera
FUMA	main: 5GHz (IEEE802.11a) (sub: 2.4GHz (IEEE802.11 g))	1.2GHz
HANZO	main: 5GHz (IEEE802.11a) (sub: 2.4GHz (IEEE802.11 g))	1.2GHz
4-legged robot	main: 5GHz (IEEE802.11a) (sub: 2.4GHz (IEEE802.11g))	1.2GHz



(a) **(b)**

Fig. 4. (a): actual camera images; (b) synthesized images from past camera image data and then the robot position information. Images at each row in (a) and (b) are images at the same time stamps.



(a)

(b)

(c)

Fig. 5. (a): Image stabilizing camera unit; (b) roll angle - left image: actual image, right image: with stabilizing algorithm; (c) pitch angle - left image: actual image, right image: with stabilizing algorithm. The above images are all taken at real-time while the camera unit is positioned on a small mobile robot.

5. Map generation/printing

Automatic 2-D map building method by laser range finder (LRF) have implemented and tested on the FUMA (Figure 6). We will extend this 2-D map building method to 3-D one by rotating the LRF for 3-D point scanning. With this method we can also obtain good robot position information.

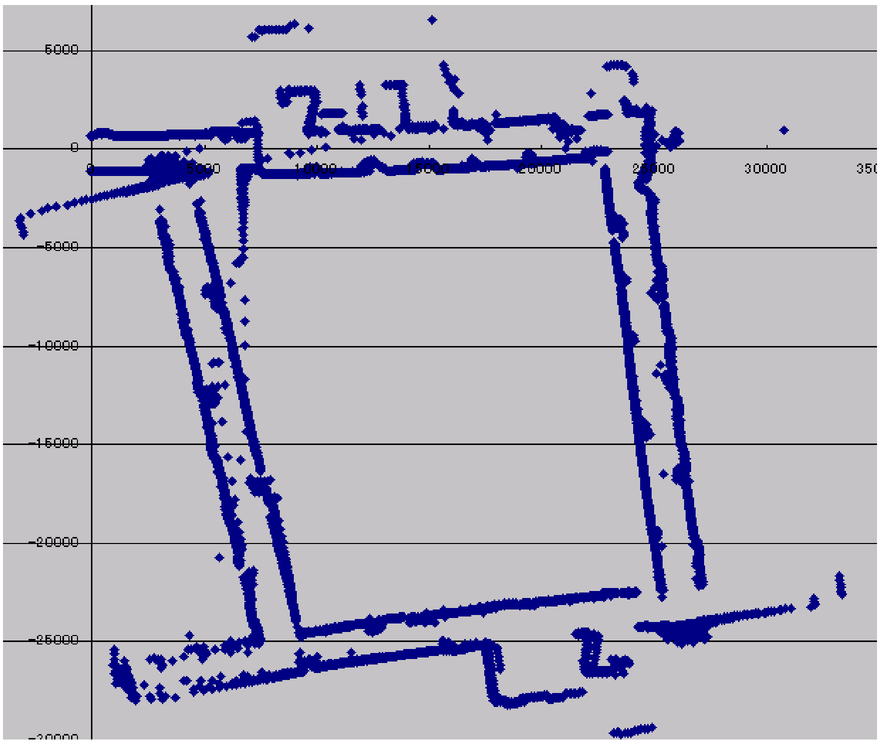


Fig. 8.. The 2-D map which is automatically built in real-time by FUMA.

6. Sensors for Navigation and Localization

Main sensors for the robot navigation are the CCD cameras. In the case of FUMA operation, the operator usually relies on the two fish-eye camera images to steer the robot, as they provide wide images of the environment with the robot in those views[3]. However, since the image resolution is very low on these two fish-eye cameras, when detailed observation of the surroundings is needed, then the main zoom in/out camera is used. For objects close to the front or rear end of the robot, the front and rear sub camera images become very useful. It is very important to use these five cameras properly according to situations of the robot at a remote site.
Within a complex damaged buildings or underground complexes, without care, the robot might cause post-disaster events to happen. For this reason, it is crucial that the robot operator has a clear view of both the robot and the environment as displayed in Figure 7. Thus, incorporating these five camera images, and with the operator station setup shown in Figure 8, it became very simple to steer the robot in any environment without bumping into surrounding objects. Moreover, the controllability of FUMA was improved with this well considered camera configuration. The critical point here is that the improved controllability greatly helps the mobility of a robot. This is because a good interface enables us to make full use of the mobility of it.

Robot position information can be obtained by laser range finder while generating a environmental map.

7. Sensors for Victim Identification

The CCD cameras, microphones and thermal sensors are used for victim identification. We will also install an IR camera for victim identification using heat of victims.

8. Robot Locomotion

There are two types of robot locomotion in our team: wheel type and legged type..

Wheel type (FUMA): this is a middle size four wheeled robot. Each side of the wheels can be driven independently. The arm mounted on the robot contributes high mobility to step over rough terrain.

Wheel type (HANZO): this is a middle size four wheeled robot. Each side of the wheels can be driven independently. The two arms on both sides of the robot contribute high mobility to step over rough terrain.

Legged type: this is a middle size four legged robot. Leg mechanism has advantages in rough terrain such as gap crossing and discrete put position selection.

Fig. 7. Images from both fish-eye lens cameras.

Fig. 8. The usual operator station setup.

9. Other Mechanisms

FUMA has an arm which gives the robot high mobility in rough terrain and presents good high position view of the environment. It also has round shape wheel covers to prevent from rolling over.

1-DOF LRF mount for 3-D point scanning.

10. Team Training for Operation (Human Factors)

Since we employ a commonly used game pad as our control interface device, most people are familiar with such controller. We configured the input commands for the robots as simple as possible so that the operator only needs to input few commands to control the robots. One of the difficulties of remote operation is that it is hard to control a robot in remote site only from the information provided by the cameras, as it does not provide enough details for us and made it difficult to recognize a robot's situation in an environment. Our remote control method which uses wide angle facing-down fish-eye robot over view images and virtually generated bird's eye view will overcome this problem and also allows the operator to control the robots with ease even without long training time. In addition, we will simulate three different level arenas in our experimental laboratory and train ourselves for the competition.

11. Possibility for Practical Application to Real Disaster Site

For practical use of our robots we need to improve the ability to control it within tough environments like water, dust, vibration, shock resistance and etc. Ordinal wireless communication system has some weakness in not well structured areas. Ad-hoc network system in wireless communication would overcome this problem.

12. System Cost

Wheel type (FUMA): a custom made robot developed in our lab. Total cost is two and a half million Japanese yen.

Wheel type (HANZO): a custom made robot developed in our lab. Total cost is two and a half million Japanese yen.

Legged type: a custom made robot developed in our lab. Total cost is four million Japanese yen.

References

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